

Preparation for Phase III (Neutral-Current Detectors) of the SNO Physics Program

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SNO is unique in its ability to address many of these questions within a single detector. Part of this capability comes from the fact that SNO is a multi-phase detector. The various phases will allow SNO to be sensitive to different physics. In Phase III of the SNO physics program, ^3He proportional counter ("Neutral-Current Detectors", NCD) will be installed inside the active D_2O volume of the detector. This will allow an event-by-event separation of charged-current and neutral-current signals, whose correlation in the first two phases (pure D_2O and salt-loaded D_2O) are not insignificant.

In the past year, we have been preparing for the NCD phase of the experiment. First, we have performed extensive studies on understanding the SNO detector response for a number of different possible geometric configurations of the NCD array. In trying to optimize for the best possible array to extract results during the third phase of SNO, one must consider a wide variety of physics topics. Certain measurements (for example, measurements which rely mostly on PMT information) will tend to favor fewer NCD counters to be deployed due to the loss of light. Other measurements (for example, those which rely on neutral current information) will tend to favor a higher number of counters, as long as the backgrounds from the counters is small compared to the NC rate. We consider a number of physics topics in determining the optimal NCD length. These topics are: charged-current (CC) flux, neutral-current (NC) flux, CC day-night sensitivity, NC seasonal variations, NC day-night sensitivity, sensitivity to neutrino oscillation parameters ($\Delta m^2, \tan^2 \theta$), sensitivity to distortion of the CC spectrum, sterile neutrinos, hep neutrinos, antineutrinos, and supernovae.

In Table I the expected uncertainties in a number of these solar neutrino observables for different deployed NCD length are tabulated. The length affects primarily the neutron detection efficiency, hence the uncertainty of the neutral-current flux. However, we found that once the deployed length exceeds a certain threshold, the gain in neutral-current sensitivity becomes marginal even if more ^3He counters are deployed. This is mainly because of the increased background level for a larger array. A large number of different geometric configurations of the NCD array and their effects on light occultation (hence their effects on the energy resolution of the photomultiplier tube array) were also studied. We found that the geometric configuration that has a good neutral-current sensitivity without a severe impact on the energy resolu-

tion of the photomultiplier tube array to be a "central" configuration, where all the counters are packed on a 1-m grid near the center of the SNO detector.

Topic	L=0.25	L=0.50	L=0.75	L_{optimal}
CC Flux	2.5%	2.5%	2.5%	0.35
NC Flux	6.1%	5.8%	6.1%	0.45
CC Day-Night	4.1%	3.8%	3.7%	0.95
NC Day-Night	4.9%	4.6%	4.0%	1.00
Sterile Neutrinos	9.6%	9.4%	9.6%	0.45

TABLE I: Summary of percentage uncertainties in several solar neutrino observables at different deployed NCD length L . $L=1$ corresponds to the full deployment of approximately 800 m of ^3He counters. L_{optimal} is the optimal L for the corresponding observable.

We also studied the long term effects counter failures have on the physics capabilities of the NCD array. After this extensive study, we have chosen the configuration shown in Figure 1 as the configuration to be deployed. The deployment is scheduled for Fall 2003.

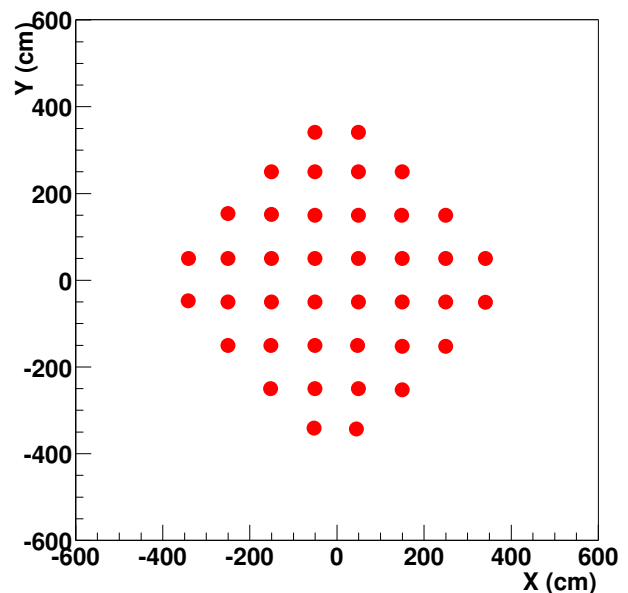


FIG. 1: Final NCD geometric configuration as view from the top of the SNO detector.